Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia Environmental Sciences 10 (2011) 2091 – 2096
Procedia Environmental Sciences

2011 3rd International Conference on Environmental Science and Information Application Technology (ESIAT 2011)

Drought Monitoring and Analysing on Typical Karst Ecological Fragile Area based on GIS

Jiang Tao [1,2,a], Zhou Zhongfa [*1,2] and Cao Shui [1,2,3]

[1]Institute of South China Karst, Guizhou Normal University, Guiyang, Guizhou, 550001, China
2The State Key Laboratory Incubation Base for Karst Mountain Ecology Environment of Guizhou Province, 550001, China
[a] taotao48@yahoo.com

Abstract

Southwest China had been suffering from an epic drought in the autumn of 2009. The study area of Tongjin vallage of Dafang county located in the typical fragile karst eco-environment area of Guizhou province was one of the worst hit sites. By meteorological monitoring here, we got plenty of meteorology data about precipitation and temperature, combine with soil erosion situation analysis of this area, setting a drought assessment model. Then, building the drought assessment system based on GIS with its strong managing and analyzing function, study showed the drought situation, grade and relief time of The study area of Tongjin vallage of Dafang county. Meanwhile, proposed the drought countermeasures in fragile karst eco-environment area such as: changing slope to ladder, planting water-holding flora, building cisterns ect.

Keywords: Geographical Information System; Karst; Drought; Impact factor; Assessment Model

1 Introduction

Parts of southwest China suffered a severe drought since September 2009, drought level of Guizhou province reached a record high. During the drought, in southwest area of Guizhou province, temperature is 1～2℃ higher than the same period of normal years, precipitation decreased by 30%～50% and it reached 50%～80% in the west compared with same period of normal years and winter precipitation reached a record low. Late April, 2010, rainfall process appeared, drought was effectively relieved in the Mid-East of Guizhou province, but the west worst hit area, for precipitation distribution was uneven, rainfall amount was limited and most of them were showers, drought relieved faint. The study area of Tongjin vallage of Dafang county located in west karst area of Guizhou province with special geological condition and natural environment, we made a comprehensive analysis about its precipitation and temperature, setting the drought assessment model for knowing more about fragile karst eco-environment area's drought condition, and proposing relevant drought countermeasures to karst area.

doi:10.1016/j.proenv.2011.09.326

2 Overview of demonstration

The study area of Tongjin vallage of Dafang county located in Bijie Prefecture of west Guizhou province covers362.54 ha, Longitude 105° 41′ 28.34E″ ～105° 42′ 57.13″ , latitude 27° 04′ 14.9″ N ～ 27° 05′ 24.6″ N,subtropical monsoon climate ,wet and dry season clear. Without severe hot summer and severe cold winter, spring is highly variable and autumn is rainy, average annual temperature is 14.03℃,maximum 33.8℃ and minimum -3.4℃,accumulated temperature greater than or equal to 10℃ is 4166℃,average annual sunshine hours for 2763.5 hours, frost-free period lasts 258 days, Average annual precipitation is 1180.4mm, the biggest precipitation is 1350.4mm presented in 1997, and the Minimum is 554.7 mm in 1989 in recently 20 years, more than half of the rainfall is concentrated in summer, especially in July to September. The study area of Tongjin vallage of Dafang county is located in the Zhuzhong river basin with a serious soil erosion, erosion area accounted for 39.2% of karst area in ZhuZhong river basin, including slight erosion area 50.59ha, moderate erosion area 31.86ha, severe erosion area 28.72 ha and extremely severe erosion area 30.82 ha. In some Steep slope area of the study area of Tongjin vallage of Dafang county as the core of Zhuzhong river basin, soil erosion is serious and rocky desertification degree is high. Vegetation coverage is lower than 5% combine with irrational human activities, soil and water massively loss leaving rocks exposed and serious land desertification [1, 2].

3 Set drought assessment factors and model of demonstration

Naturally, drought is related to contingent or cyclical precipitation, reduction, big change and uneven distribution of precipitation directly cause drought, temperature and soil water-holding capacity affect drought level [3], based on above impact factors, set assessment model and assess the drought condition.

3.1 primary impact factor- precipitation. Set a Variable R, it represents precipitation of a special period, make a comparative analysis with the condition of same period of former years to see the way it changes, the process needs a medium variable-- Precipitation Abnormity Percentage (pa), it represents deviate degree of precipitation between this period and the same period of normal years. Equation is [4]:

$$p_a = \frac{R - \overline{R}}{\overline{R}} . \tag{1}$$

R: precipitation of a specify period; $\overline{R}$: average precipitation of the same period in former years. When Pa is positive, it means precipitation is large and above the average level of same period in former years, when Pa is negative, it means precipitation is rare and below the average level of same period in former years, it directly reflects local rainfall condition and effect drought condition. But this equation does not refer to the other factors which are significant to drought formation: temperature and soil water-holding capacity.

3.2 impact factor- temperature. Temperature has a significant effect on evaporation and the two is mainly proportional. Combined with precipitation, comes a drought assessment model based on drought monitoring index [5]:

$$I = a_1 \times r_{30} / rj_{30} + a_2 \times p / pj + a_3 \times t_{30} / tj_{30} . \tag{2}$$

r_{30} and t_{30} are total precipitation and average temperature of recently 30 days; rj_{30} and tj_{30} are their average for many years; p is precipitation of 5 months before half a year; P_j is the average value of P for many years; a_1, a_2, a_3 are weighting coefficients.

Precipitation plays a leading role in this equation, value of it directly effect current drought condition, so its coefficient is on the high side. For soil itself has water-holding capacity, rainfall from last season will effect the current water-holding capacity and drought condition, we select the data of 5months before half a year, influence is relatively slight, so its coefficient is on the low side.

3.3 impact factor-soil erosion situation. Soil erosion which caused by exterior force such as water, wind and gravity means damage and loss to water and soil resources and land productivity, soil erosion gives rise to large soil moisture loss and water-holding capacity decrease. Take soil erosion as one impact factor to drought assessment model, weighting coefficient is defined as the soil erosion grade.

Table1 Classified Statistical Date of Demonstration Soil Erosion Situation in 2010

Grade	Area（ha）	Percentage (%)	Spot (piece)	Spot percentage (%)
light	50.59	13.95	80	9.85
moderate	31.86	8.79	132	16.23
high	28.72	7.92	44	5.42
severe	30.46	8.40	69	8.48

The study area of Tongjin vallage of Dafang county located in the fragile karst eco-environment area with serious soil erosion and poor soil water-holding capacity, rainwater couldn't infiltrate well and formed surface or underground runoff, soil water content is low. In addition, the precipitation reduction and temperature rise exacerbated the drought. Soil water-holding capacity is reflected by weighting coefficient, take all factors into account, coefficient a_3 is set at -0.2. Through the analysis of precipitation, average temperature and drought actual condition in former years, a_1, a_2 is set at 0.6 and 0.2 respectively. (Table 2)

Table 2 Drought Monitoring Index and Grade

Drought Index	Drought Grade
$I>0.85$	None
$0.55<I\leq 0.85$	Light
$0.25<I\leq 0.55$	Moderate
$I\leq 0.25$	Severe

4 Set drought model based on GIS for Fragile karst eco- environment area

Meteorological station was connected to GIS and keep the received meteorological information directly enter GIS, then, these date were managed and analysed uniformly by system database. It made ideal simulated results with equation (2). GIS transformed the Model to its language and analyse the date by powerful analysis function, then add drought assessment early-warning function into drought assessment system. Technical procedure as follow: (Fig.1)

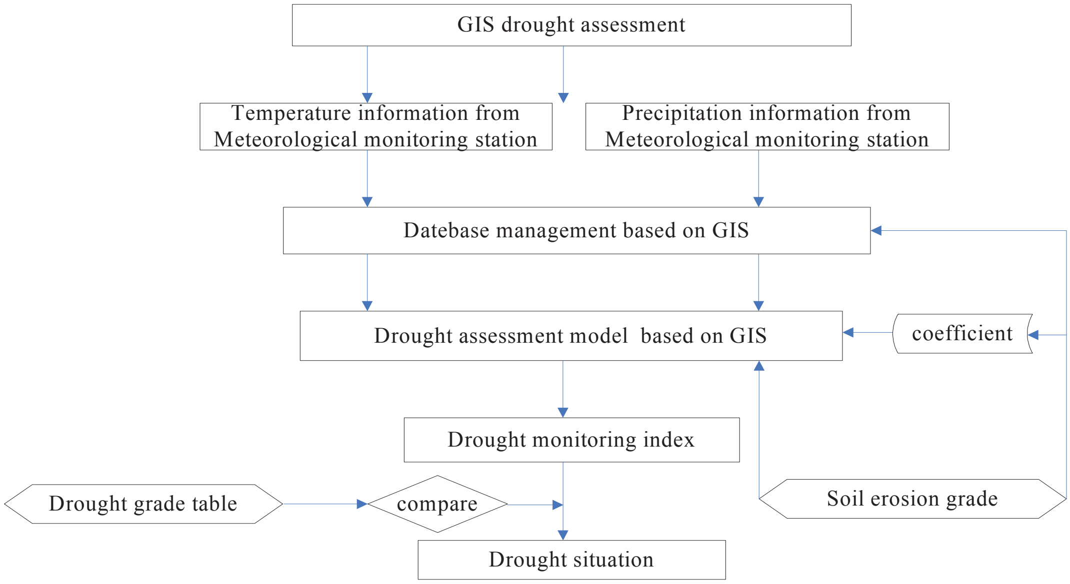

Fig.1 Information system implementing procedure

4.1 geographic information system function

4.1.1 meteorological data will be automatically recorded into geographical information system and stored in Excel format, system make a classifying management for these date. Based on ArcGIS Engine Thematic map function, this module automatically generate precipitation histogram and temperature curve graph.

4.1.2 spatial analysis module of GIS convert drought analysis model to computer language, carry on modeling processing based on meteorological data, analyse monitoring index. It has drought monitor function.

4.2 precipitation and average temperature data analysis. By systematic analysis and systematic synthesis of precipitation and temperature information form The study area of Tongjin vallage of Dafang county, it shows as follow chart:

Table 3 Meteorological Data Information

Month (2008-2009)	Precipitation (ml)	Average Temperature (℃)	Month (2009-2010)	Precipitation (ml)	Average Temperature (℃)
September	151.2	19.0	September	45.9	19.5
1. October	126.6	14.5	2. October	81.3	13.3
November	109.1	8.3	November	14.5	7.8
December	9.6	4.7	December	29.6	4.8
January	24.2	1.9	January	7.5	4.5
February	21.2	9.3	February	11.8	9.8
March	42.8	9.1	March	17.4	9.9
April	100.9	12.3	April	49.0	11.1
May	57.2	16.1	May	127.3	16.2
June	126.0	19.3	June	205.5	17.2

Form above, The study area of Tongjin vallage of Dafang county’s precipitation of September 2009～April 2010 is 257mm dropped 328.6mm by compared with precipitation of the same period of 2008～2009. It is the leading factor directly caused the drought. Comparative analysis result of different time period shows that the temperature of September 2009～March 2010 is flat or greater than it of the same period of 2008～2009, it begin to get down since April 2010 compared with April 2009. With the background of precipitation reduction, higher temperature accelerated water evaporating and soil moisture lossing.

4.3 drought monitoring index calculation. Meteorological data from GIS analysis integrate with drought assessment model and weighting coefficient of soil erosion impact factor, we figure out the drought monitoring index, referring to it, we calculated the numerical value of I for each month since September 2009, results showed as follow:

Table 4 Drought Grade Condition

Year	Month	Drought assessment index (I)	Drought Grade
2009	September	0.186	severe
2009	3. October	0.465	moderate
2009	November	0.186	severe
2009	December	0.433	moderate
2010	January	0.078	severe
2010	February	0.313	moderate
2010	March	0.246	severe
2010	April	0.362	moderate
2010	May	0.838	slight
2010	June	0.734	slight

From it, the study area of Tongjin vallage of Dafang county suffered drought from September 2009 to April 2010, drought grade is moderate or severe. According to the information from The National Weather Service, since late April 2010, by virtue of rainfall process coming to southwest China, drought situation of east Guizhou province was effectively relieved, but precipitation in the west and south of Guizhou province is mainly in the form of showers with a small amount and uneven distribution, drought of this area had not obviously relieved. According to the precipitation and temperature information of May and June 2010, which was recorded in GIS via weather station, drought of Defang-Tongjing demonstration had been efficiently relieved from moderate and severe grade to the slight grade. Both the results are consistent.

To sum up, drought assessment system based on GIS have correctly deal with meteorological data analyzing and filing, defined the drought grade of demonstration is moderate and severe and occurring time analysis is consistent with the real situation of southwest china drought, the accurate prediction provided effective basis for drought early-warning and decision-making.

4.4 meteorological disasters caused by drought in fragile karst eco-environment area. In demonstration area, the drought caused river levels falling and rivers weekly recharged by surface water, water resource of people living and industry production relied on groundwater resource exploitation for a long time, it further exacerbated local ecological issues such as groundwater level decline, funnel area expand, land subsidence and vegetation degeneration ect.

5 Conclusions

Upon the drought assessment of the study area of Tongjin vallage of Dafang county by drought assessment model based on GIS, we learned about the drought condition in fragile karst eco-environment area of southwest china, it lays a good foundation for drought early-warning and drought against work in karst area. Meanwhile, some reasonable measures should be taken to protect our environment such as changing slope to ladder, planting water-holding flora, building cisterns, using drip irrigation technology, all of these will play a positive role in preventing water waste, soil erosion and drought worsen. Ecological issues like reduction of agricultural production, water supply shortage, rocky desertification and ecological deterioration caused by drought have been giving rise to the broadly and highly concerning throughout all of the world, thus , the work of setting drought assessment model and establishing early-warning systems is significant in social development. Drought in fragile karst eco-environment area is affected by special karst geologic condition and macro climate background. It is a result from interaction of natural factors and human activities. We must redouble our efforts to protect and improve the ecological environment. Achieve harmonious co-existence between man and nature and promote the society all-round development.

Acknowledgments

This study was funded by the State Science and Technology Key Program in the National Twelevth-Five-Year Plan of the project of the Comprehensive Control Technology and Demonstration for the Gorge Desertification in the Karst Plateau (Grant NO. 2011BAC09B01)， the Outstanding Young Scientists Fund Program of Guizhou Province (Guizhou S&T Talent Contract 2009-18), the State Science and Technology Key Program in the National eleventh-Five-Year Plan of the Ministry of Science and Technology of China(Grant NO. 2007BAD53B01), the Science and Technology Program of Guiyang Municipal Government(Guiyang S&T Industry Contract 2010-1-81), the International Science and Technology Cooperation Program of Guizhou Province(Guizhou S&T International Cooperation Contract 2009-700127).
*author for corresponding.

References

[1] B. Li, Z.F. Zhou and K.CH. Huang: Analyzing degradation ecological landscape pattern for the karst plateau on the basis of GIS technologies. Plant Growth Modeling, Simulation, Visualization and Applications. Proceedings － PMA09Vol.11(2009), p.449～452

[2] Z.F. Zhou, B. Li and X.Y. Yang: Analysis on remote sensing monitoring and spatial pattern of landscape for karst plateau in Guizhou province. Journal Of Anhui Agriculture SciencesVol.31(2009), p.15391～15393

[3] SH. Sha, Y. Cao: The meteorological disaster assessment system based on GIS--drought evaluation model of research. Science＆Technology InformationVol.31 (2009), p.5～6

[4] J.H. Zhou, L.P. Li and A.M. Qin: Study on the determination of meteorological drought and drought climate changes in Shanxi Province. Agricultural Research in the Arid AreasVol.3 (2010), p.240～248

[5] Y.H Li, C.P. Zhao: Study and Application on Real Time Monitoring Target to Arid Spring in Taiyuan. Shanxi Coking Coal Science & Technology Vol.1 (2007), p.13

[6] X.Y. Yang, Z.F. Zhou and C.H. Zou: Based on Landscape Level Spatial Pattern Analysis in Karst Rocky Desertification Landscape. Journal of Guizhou Normal University (Natural Science)Vol.3 (2010), p.23～27